Seattle Public Utilities
Seismic Study Summary

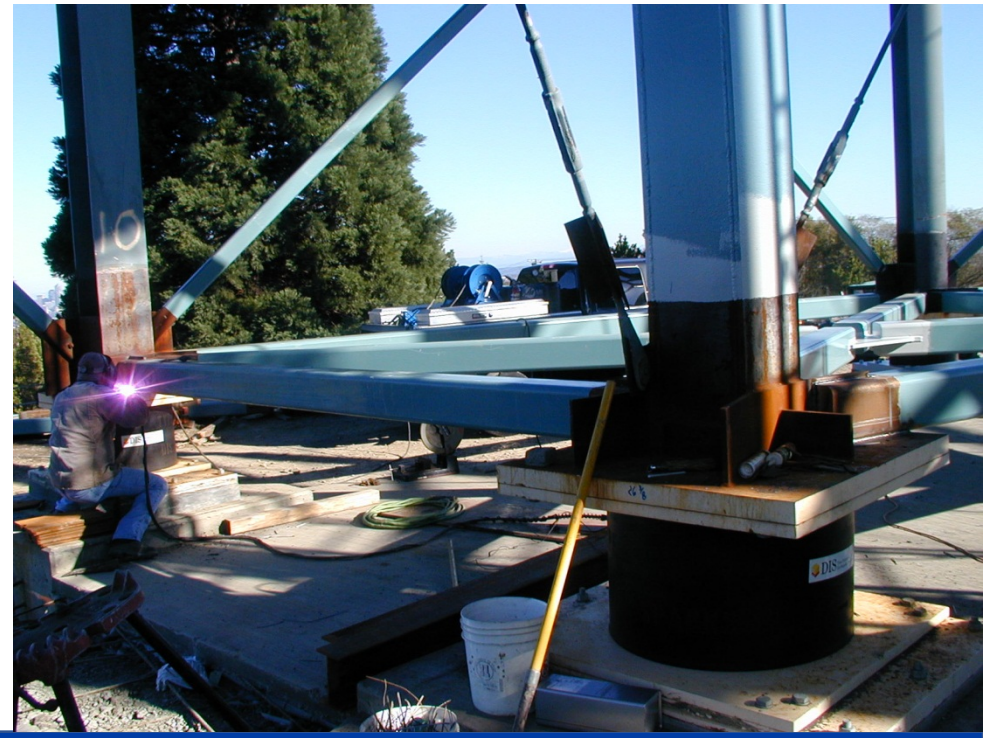
December 17, 2019

Presentation Outline

- Background
- Seismic Hazards
- Seismic Study Findings
- Seismic Mitigation Recommendations

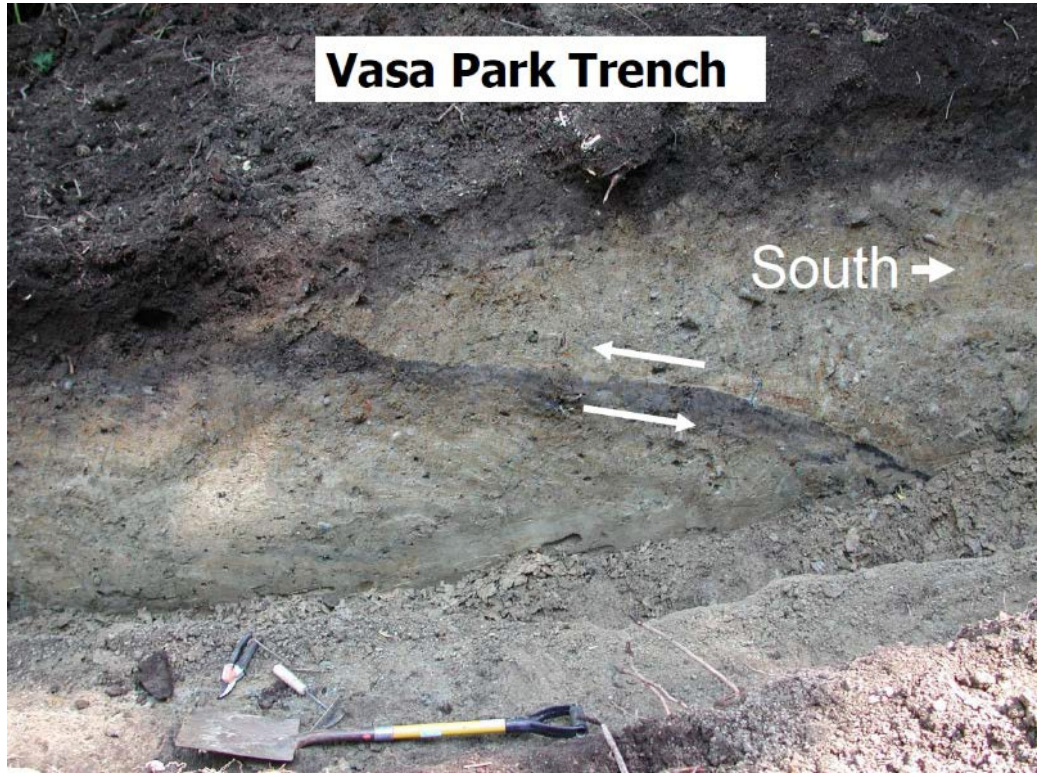
SPU Seismic Mitigation Program History

- Seattle Water Department Seismic Vulnerability Study (Cygna Energy Services, 1990)
- Earthquake Loss Modeling of the Seattle Water System (Kennedy Jenks Chilton/USGS, 1990)
- SPU Seismic Upgrade Program (e.g., OCC, Myrtle Elevated Tanks, Barton Standpipe, etc.)
- Performance of Water Supply Systems in the February 28, 2001 Nisqually Earthquake (system post-earthquake hydraulic modeling, Water Research Foundation, 2008)



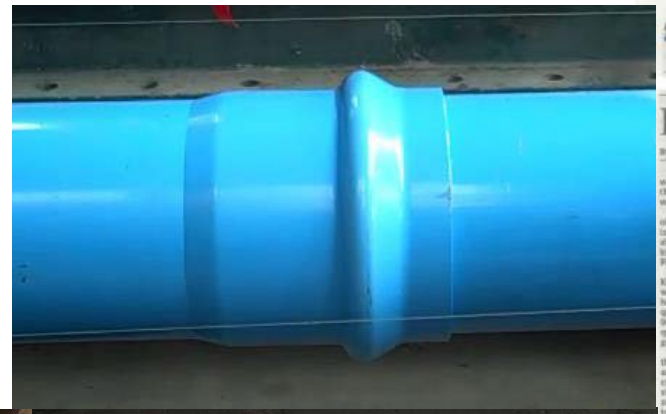
New Developments (since 1990)

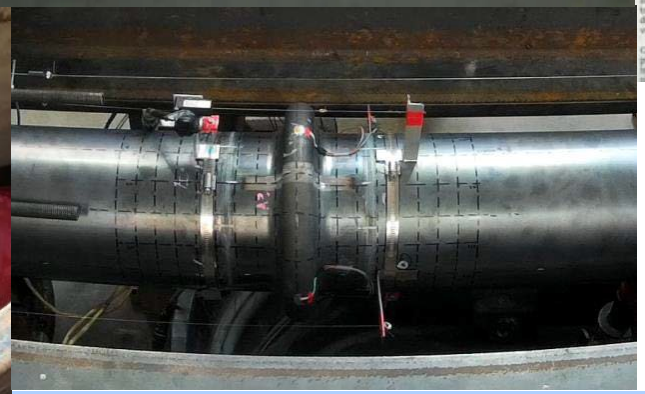
- Puget Sound region surface faults determined to be active (e.g., Seattle Fault, South Whidbey Island Fault, Tacoma Fault, etc.)
- Migration from 10% probability of exceedance in 50 years (475 year return interval) design earthquake to 2% probability of exceedance in 50 years (2475 year return interval) design earthquake

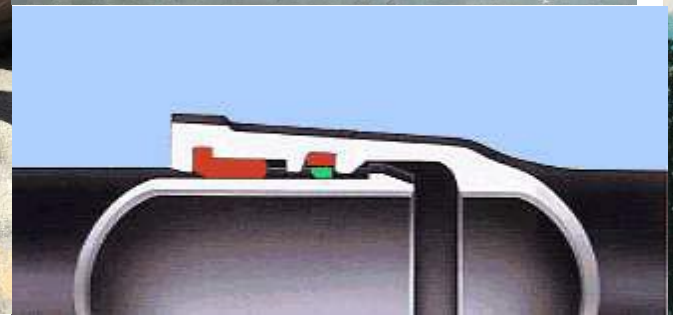


New Developments (since 1990 - cont)

- Earthquake Experience (e.g., Northridge, Japanese, Chilean and New Zealand events)
- Earthquake-resistant ductile iron pipe becomes available in U.S.





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U.S. NEWS

Los Angeles Tests Water Pipes That Stand Up to Quakes

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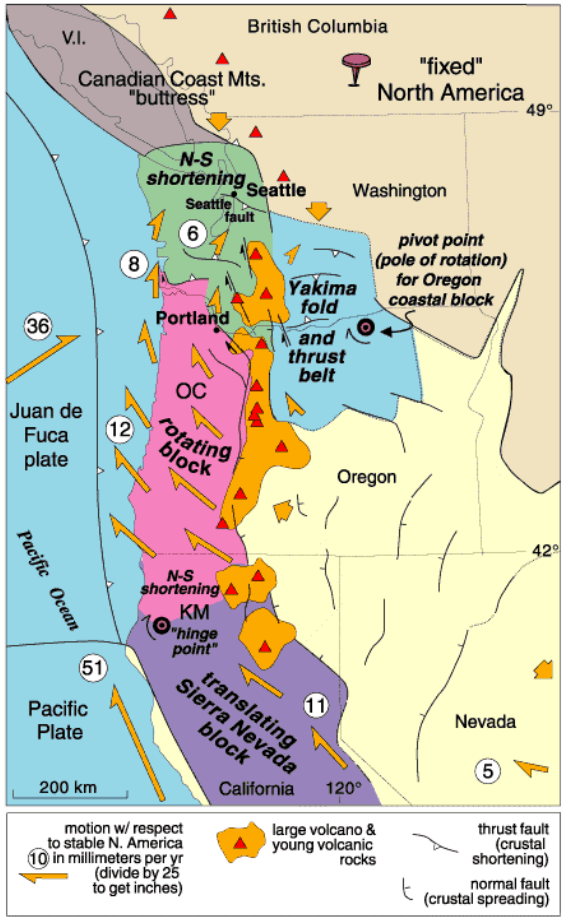
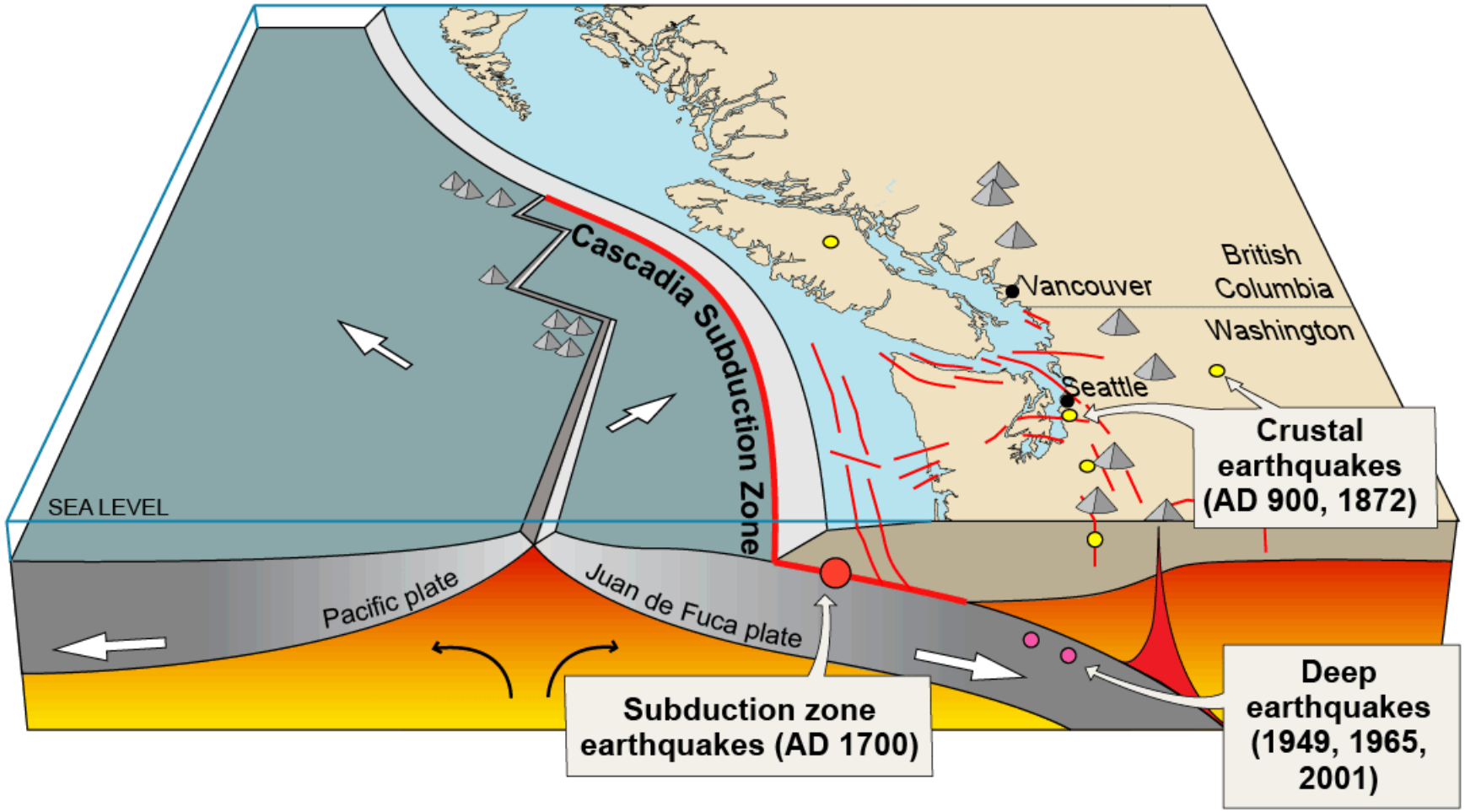
Seismic Vulnerability Assessment Project Goals

- Preliminary seismic vulnerability assessments for all critical water transmission and distribution system facilities
- Hydraulic modeling of post-earthquake water system performance
- Establish post-earthquake water transmission and distribution system performance goals
- Develop planning level mitigation measures, cost estimates and timeframe to meet service level goals.
- Define seismic design standards for water transmission and distribution pipelines.

Earthquake Source Zones





Source	Max. Size	Recurrence
Subduction zone	M 9+	200–600 years
Deep Juan de Fuca plate	M 7+	30–50 years
Crustal faults	M 7+	Hundreds of years?

Volcano

Active crustal fault

Active plate boundary fault

*figure modified from USGS Cascadia earthquake graphics at http://geomaps.wr.usgs.gov/pacnw/pacnweq/index.html

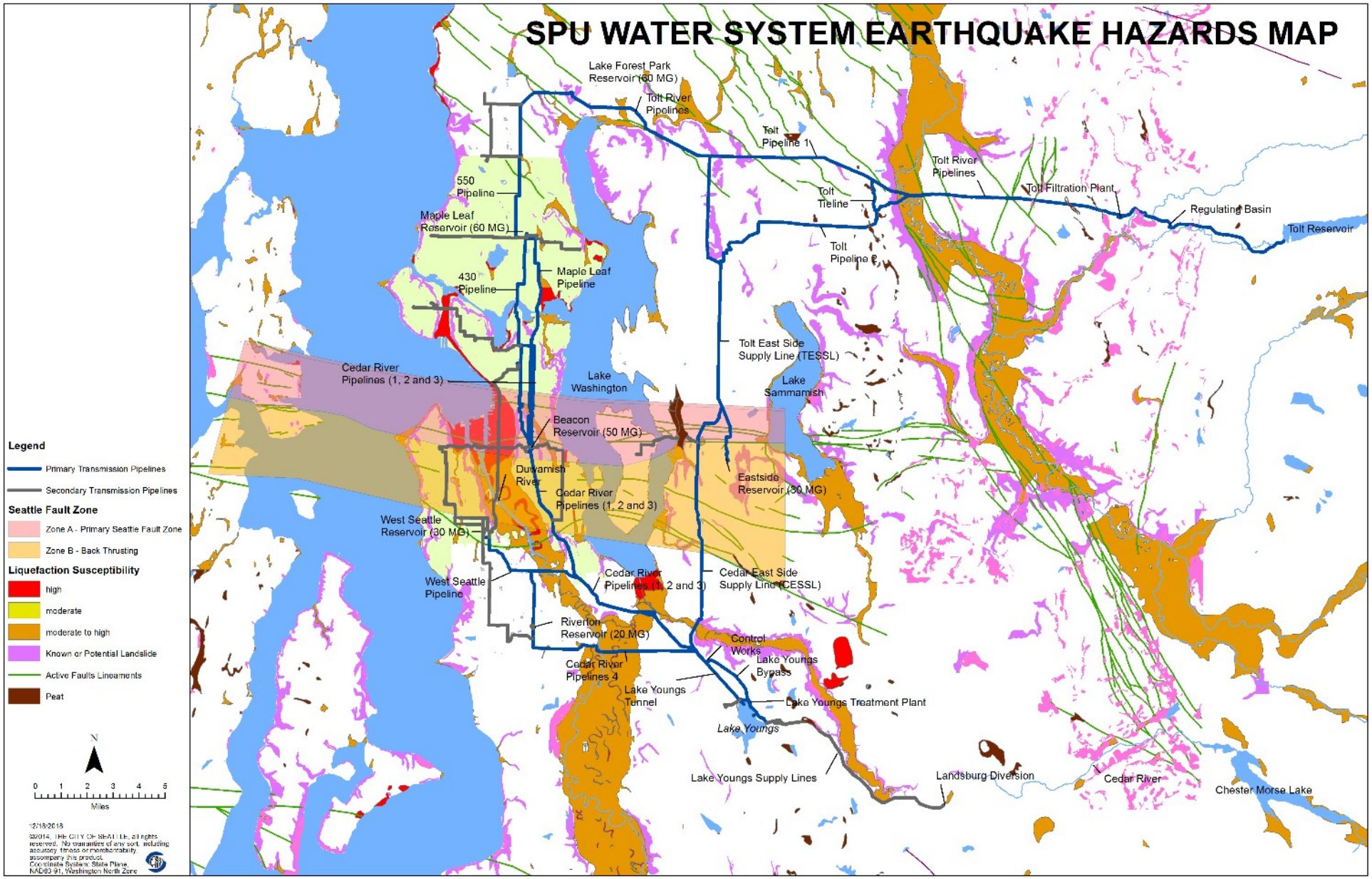
Seattle Earthquake Likelihood in the Next 50 Years

- 15% to 20% chance of catastrophic earthquake, similar to 2011 Christchurch or Tohoku earthquakes
  - 14% chance of M9 (plus or minus) Cascadia subduction earthquake
  - 5% chance of M6.5 or larger Seattle Fault earthquake
- 85% chance of at least one intraplate earthquake “similar” to the 2001 Nisqually earthquake

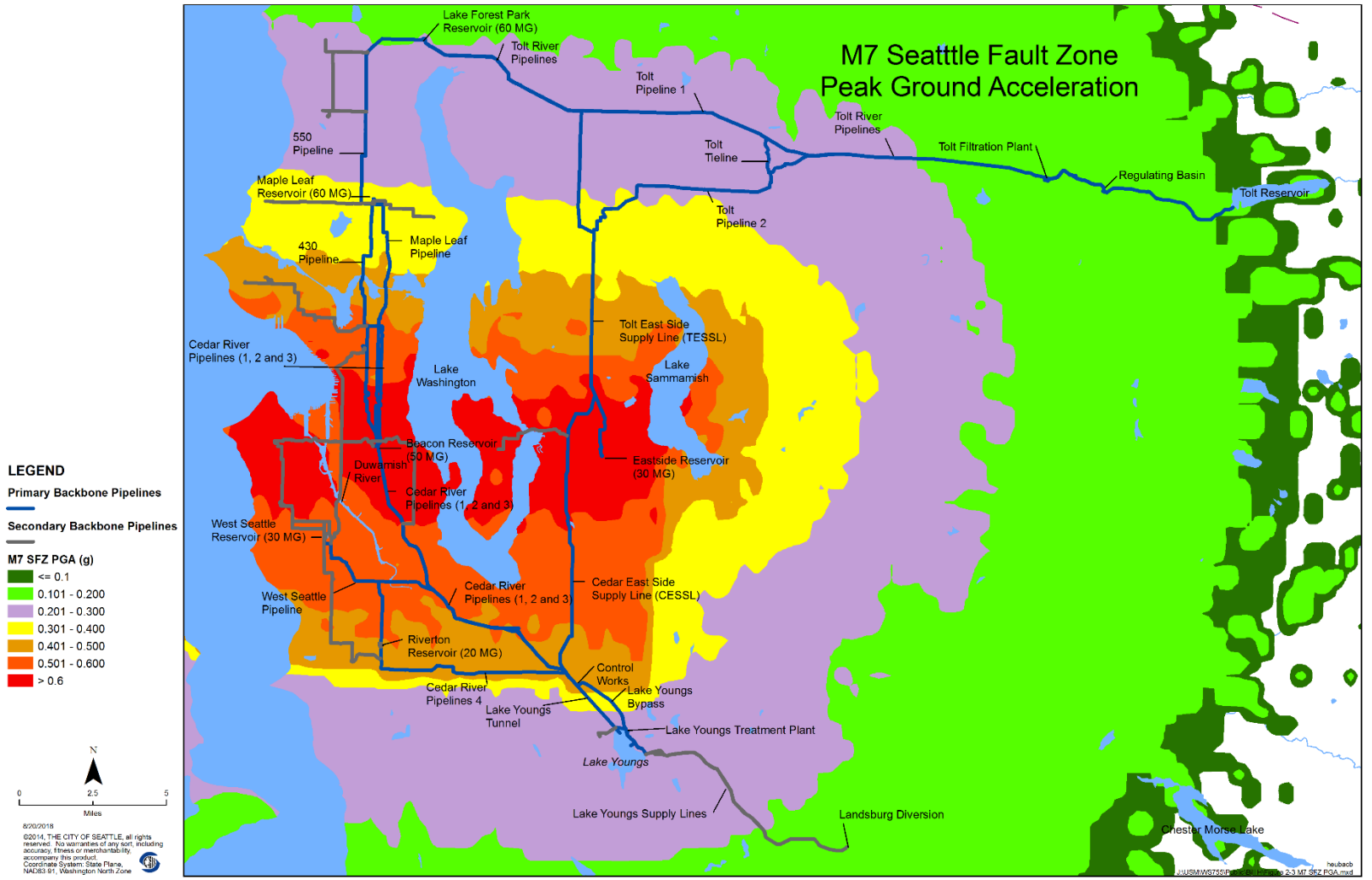
Seismic Hazard Analysis - Scenarios

- Three Scenarios
  - M7.0 Seattle Fault
  - M9.0 Cascadia Subduction Zone
  - 0.02 Probability of Exceedance in 50 Years Ground Motions
- Hazards Evaluated
  - Ground Shaking Intensity (PGA)
  - Permanent Ground Displacements

SPU Water System Seismic Hazard Map

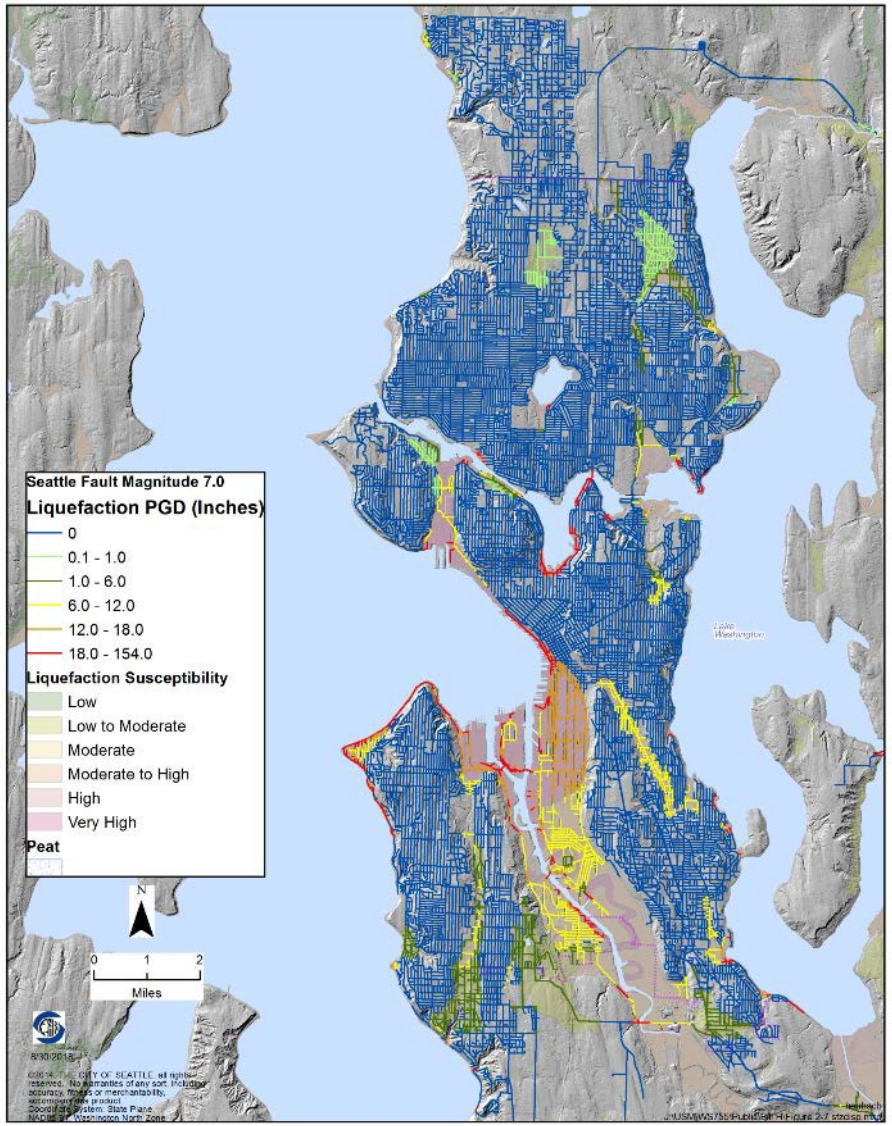


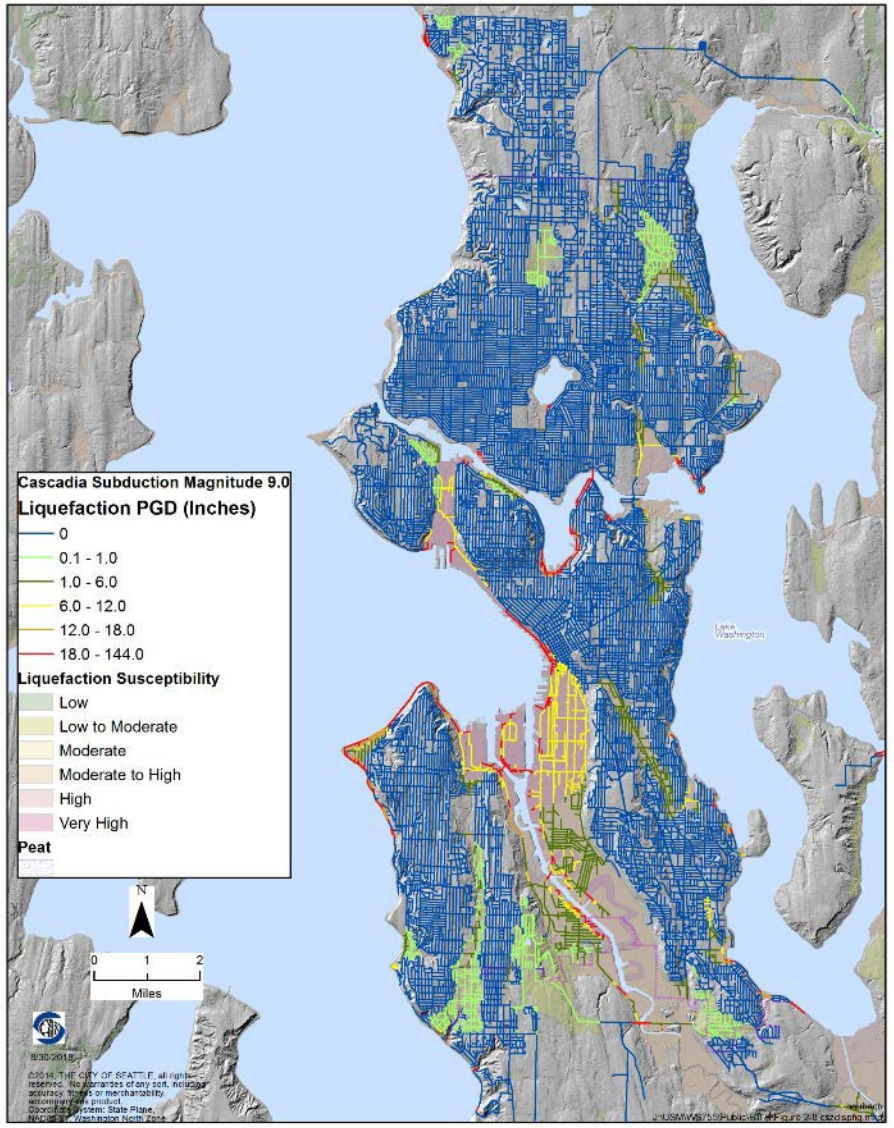
M7 Seattle Fault Zone Peak Ground Acceleration



Earthquake Hazards – Liquefaction

Permanent Ground Displacement





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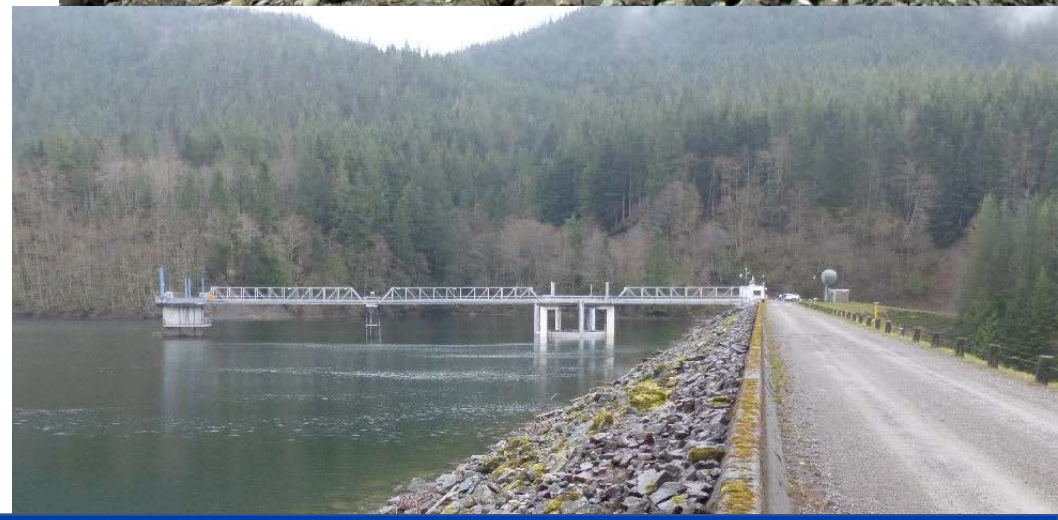
Seismic Vulnerability Assessments

- “Vertical” Facilities
  - Watersheds
  - Treatment Plants
  - Reservoirs/Tanks
  - Pump Stations and Gatehouses
  - Support Facilities
- Pipelines
  - Transmission
  - Distribution

Watersheds

- Dams – Meet FERC requirements
- Landslides
  - Minor impacts in M7.0 SFZ and M9.0 CSZ events
  - Moderate or more severe impacts possible for building code ground motions
- Other Facilities
  - Tolt intake bridge connections
  - Tolt screenhouse
  - Landsburg Tunnel Gatehouse



Treatment Plants

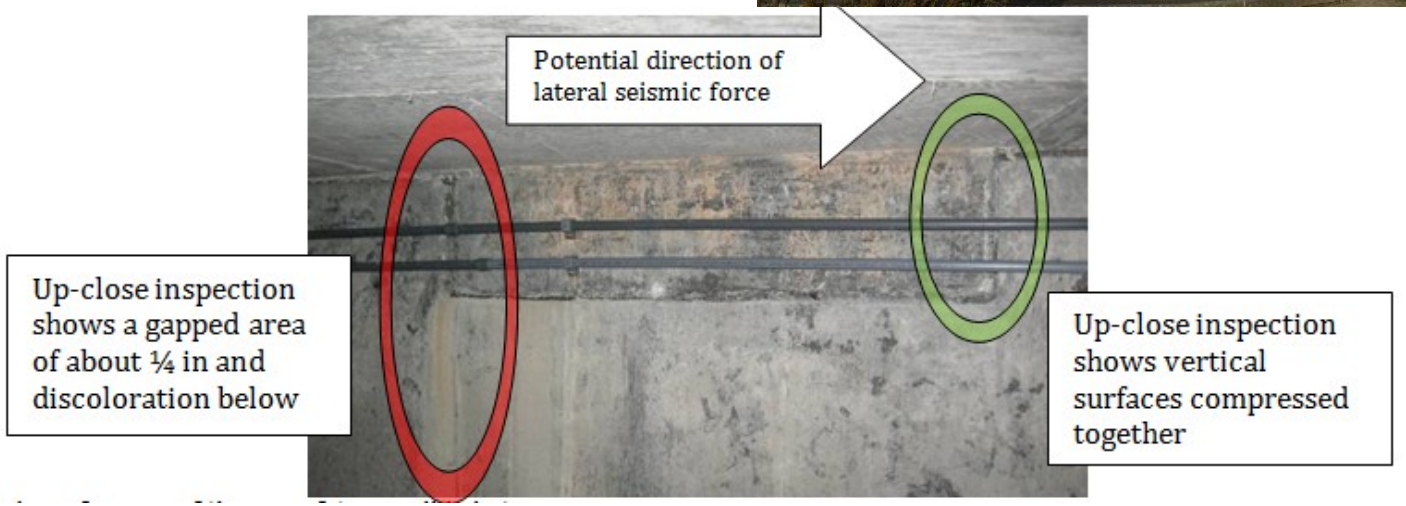
- Structural Performance – generally good
- Some Nonstructural Concerns
- Sloshing in Basins
- Onsite Emergency Power
- Clearwells – some damage (particularly for building code ground motions) but expected to remain functional

Regional Reservoirs and Tanks

- Reservoirs
  - Riverton Reservoirs Is Most Vulnerable
  - Eastside Reservoir Also AConcern
  - Damage Possible to Other Reservoirs But Most or All Others Are Expected to Remain Functional
- Elevated Tanks and Standpipes: All Are Vulnerable to Code Level Ground Motions

Myrtle #2

Eastside Reservoir After Nisqually Earthquake:



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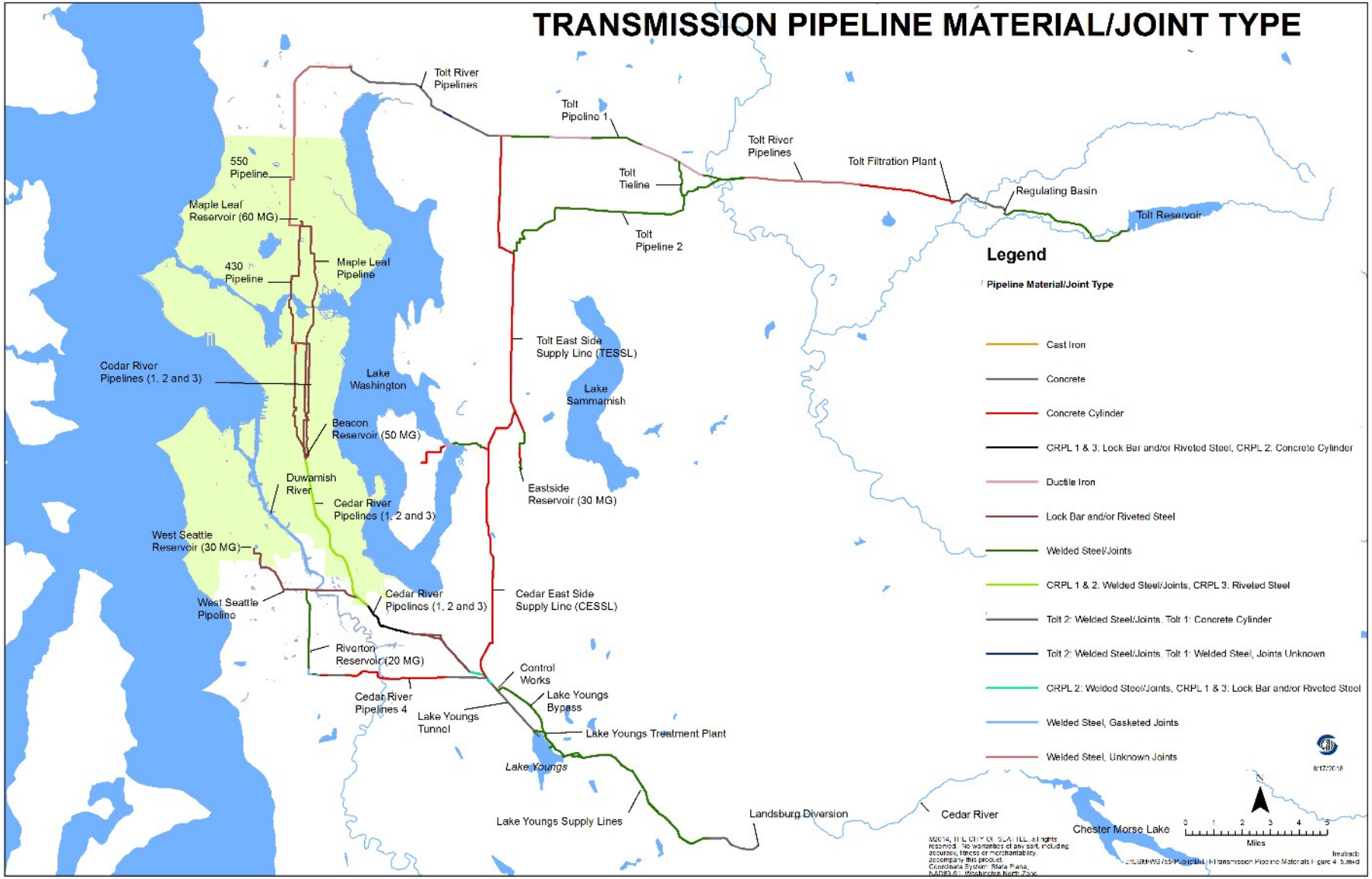
Regional Pump Stations

Several Pump Stations Are Vulnerable But Most of Vulnerable Pump Stations Are Not Critical

Transmission Pipelines

Transmission Pipelines



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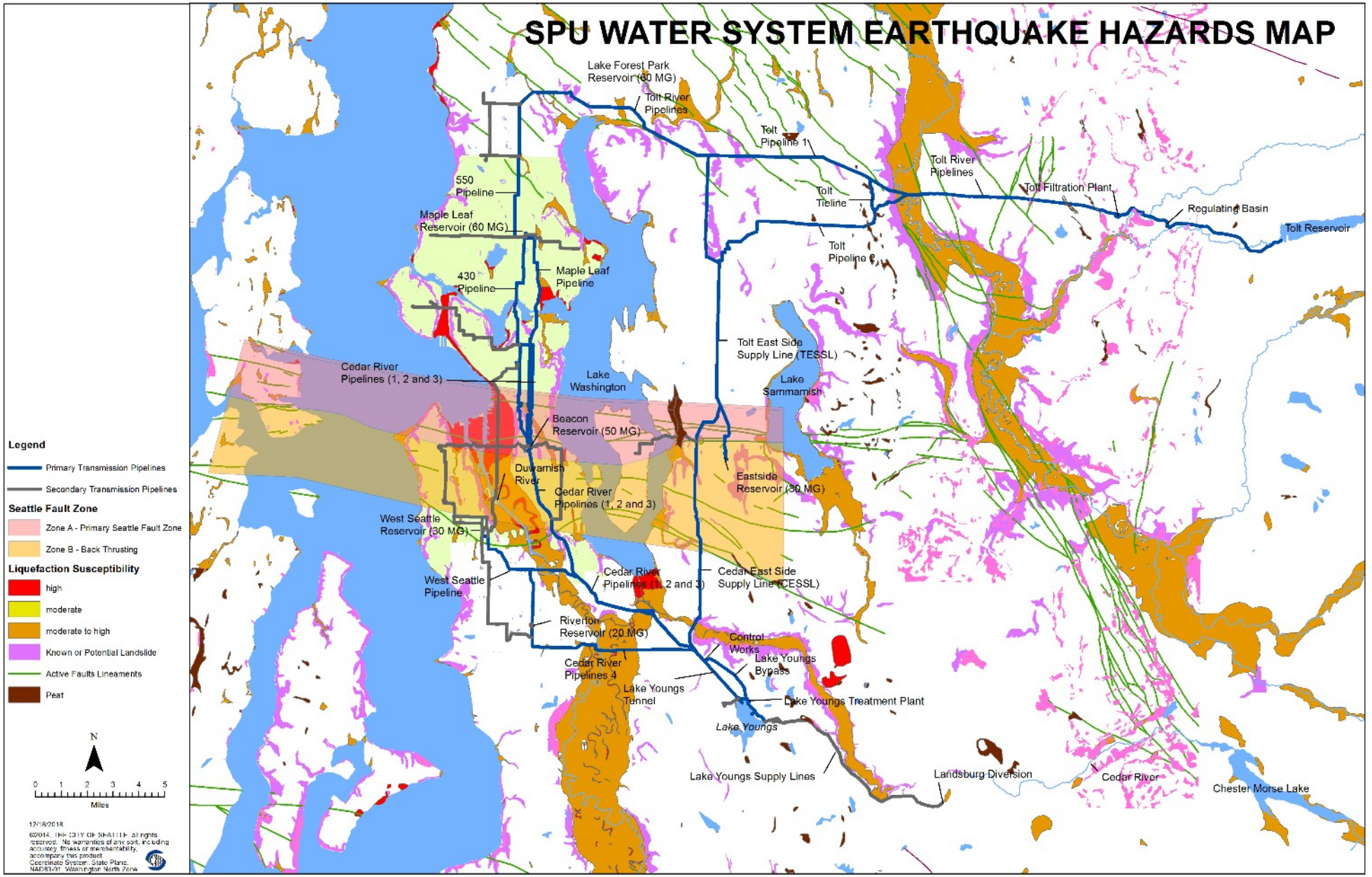
SPU Water System Seismic Hazard Map



Vulnerability Assessment Findings Summary

- For a catastrophic earthquake (15% to 20% chance in next 50 years)
  - Loss of Cedar and Tolt Transmission Systems Likely
  - Loss of Eastside Supply Line Likely
  - Distribution Pipeline Failures
    - M7 SFZ Scenario: ± 2000 failures
    - M9 CSZ Scenario: ± 1400 failures
  - Most Terminal Reservoirs Remain Functional
  - Loss of Over One Dozen Critical Facilities
  - Loss of Water Pressure Throughout Direct Service Area Within ± 24 Hours
- Mitigation plans balancing risk vs cost

Mitigation Approach – Short Term Measures (Next 15 to 20 Years)

- Enhance emergency preparedness and response planning
  - Earthquake-specific response plan
  - Significantly augment pipeline repair material stocks
  - Assess adequacy/improve emergency drinking water
- Develop/implement isolation and control strategies
  - Reservoir isolation valves
  - Explore isolating areas of large amounts of pipe damage
  - Add valves to make isolation easier

Mitigation Approach – Long Term Measures (Next 50 Plus Years)

- Build It Right (Now Until Forever)
  - Use earthquake-resistant pipe when pipe is replaced
  - Design new facilities to remain functional
- Upgrade Vulnerable Critical Facilities (Next 50 Plus Years)
  - Most vulnerable transmission pipelines locations (Cedar system has top priority)
  - Critical facilities
    - Large volume reservoirs
    - Key pump stations and support facilities
    - Life-safety

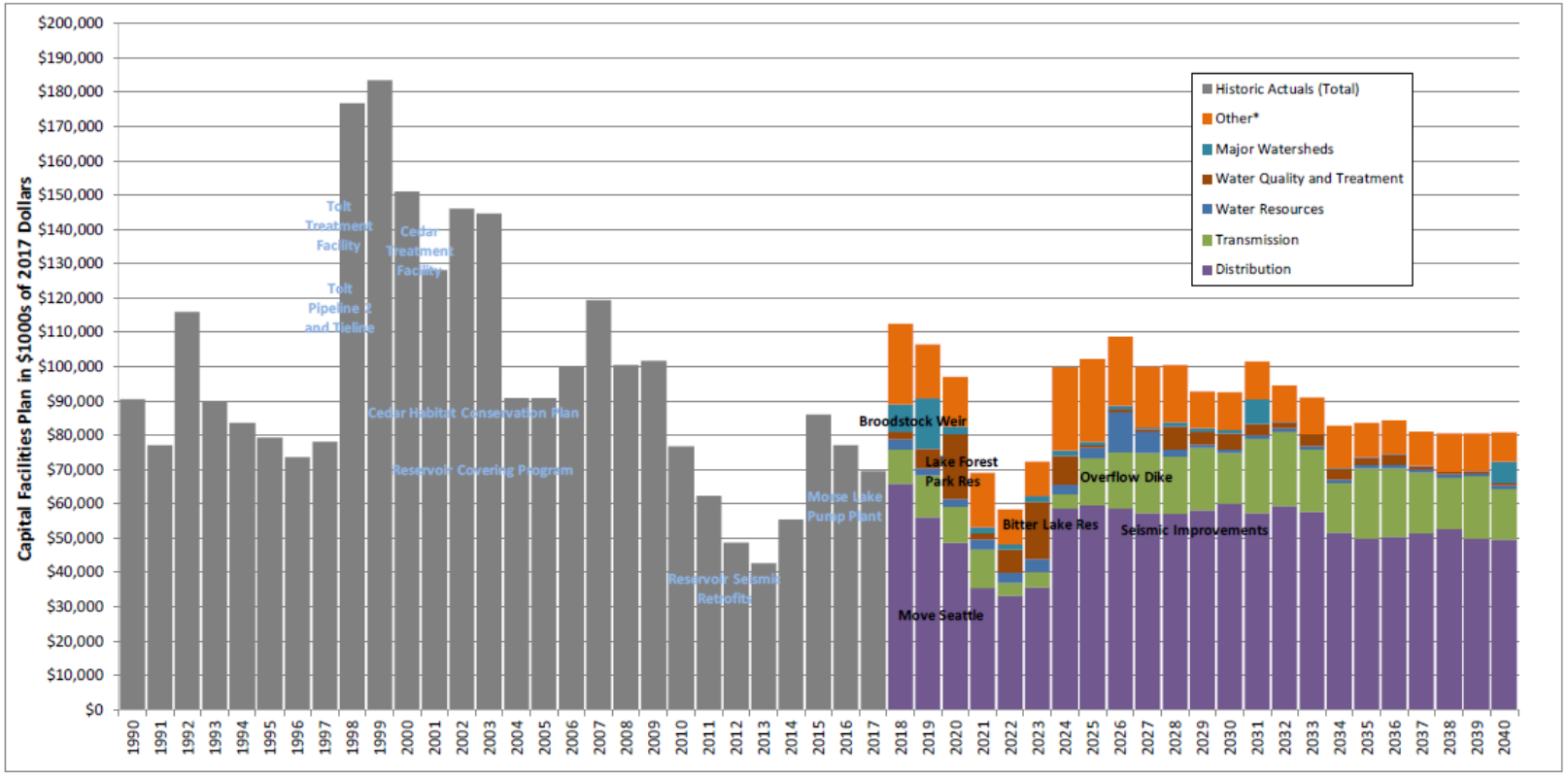
Seismic Resilience Recommendations

- $15 to $20 million per year – 50+ years
- Refer to Seismic Study Executive Summary for a list of proposed projects
- Options analysis for all projects
  - Proactive upgrade options
  - Operational response until replacement
  - Example: a vulnerable pipe crossing
    - Proactive replacement/seismic upgrade of pipe
      - Open trench replacement
      - Slip-line pipe
    - Wait until condition-related replacement
      - Install emergency connections
      - Place spare pipe immediately adjacent

Seismic Projects and CIP Planning

- Seismic projects included in 20-year CIP projections
- Seismic is one of many drivers
  - Aging infrastructure
  - Move Seattle coordination
  - Climate change
  - Dam Safety
  - Regulatory requirements
  - Environmental needs
  - Technology advancements

Historic and Proposed Capital Facilities Plan Spending through 2040
(2018-2023 Adopted CIP, plus 2024-2040 Estimate, in thousands of 2017 dollars)



* Other includes Fleets, Facilities, Security, Information Technology, SCADA and other miscellaneous projects.

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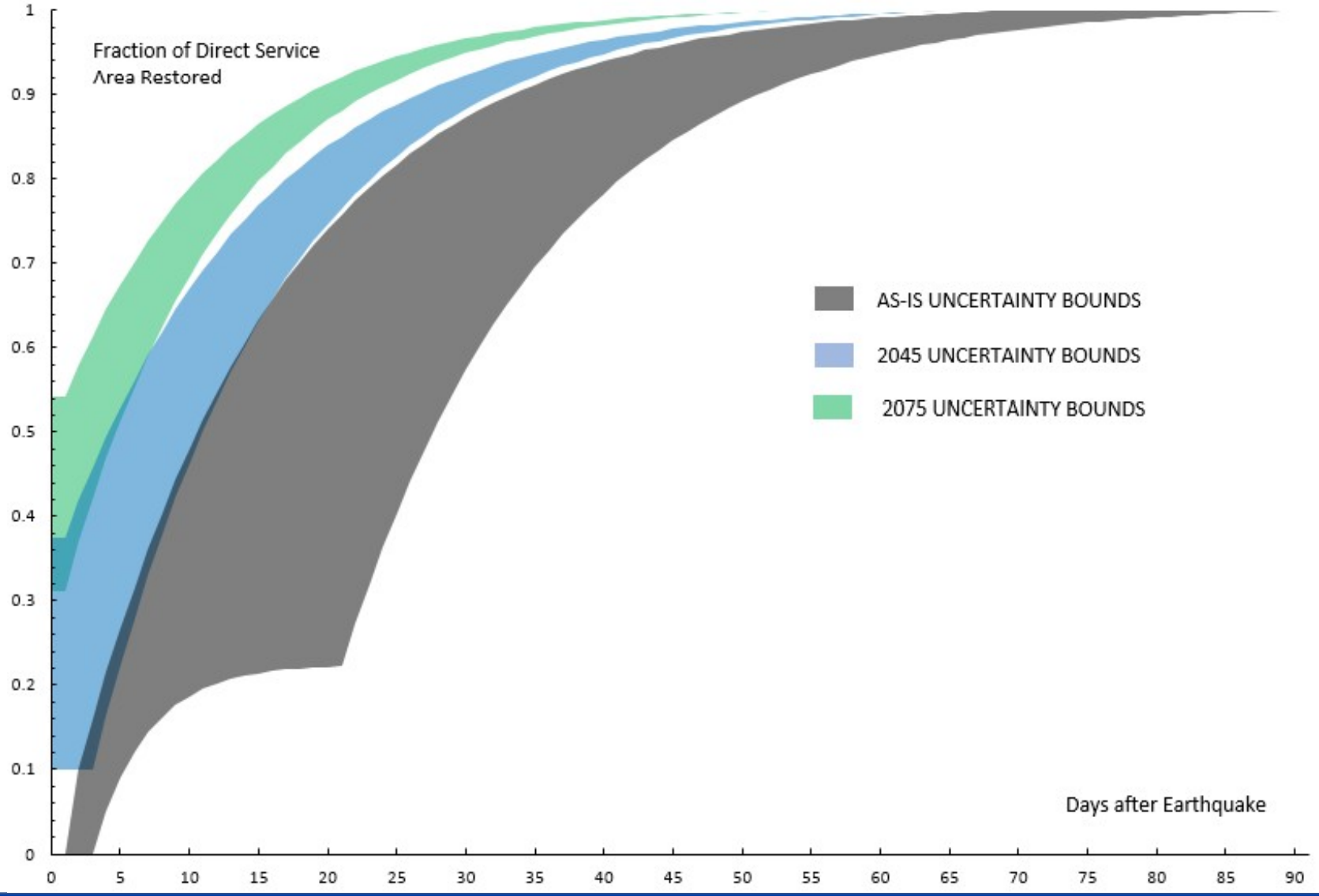
Direct Service Area Restoration Projected Improvement



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Questions?